STAR LIGHT, STAR BRIGHT, REALLY BIG STAR I SEE TONIGHT

INSTRUCTIONS

Overview:

Through experimentation with flashlights, students discover the factors affecting star brightness include the distance the star is from Earth and the size of the star. Using flashlights, students work together to model a scaled size and distance comparison of five of the brightest stars that can be seen from Earth. Students the brightness of the stars and compare their values to those of astronomers.

Objectives:

The student will:

- list the factors that affect star brightness;
- convert metric units; and
- compare the modeled brightness of five different stars visible from Earth.

Targeted Alaska Grade Level Expectations:

Science

[8] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

[8] SD 4.2 The student demonstrates an understanding of cycles influenced by energy from the sun and by Earth's position and motion in our solar system by comparing the brightness of a star to its distance and size.

Math

[8] MEA-1 The student demonstrates understanding of measurable attributes by converting measurements within the same system (English or metric).

Vocabulary:

brightness—The luminance of a body, apart from its hue or saturation, that an observer uses to determine the comparative luminance of another body. Pure white has the maximum brightness, and pure black the minimum brightness.

celestial—Relating to the sky or the heavens. Stars and planets are celestial bodies.

diameter – 1. A straight line segment that passes through the center of a circle or sphere from one side to the other. 2. The length of such a line segment.

light-year – The distance that light travels in a vacuum in one year, equal to about 5.88 trillion miles (9.48 trillion kilometers).

luminance – Also called luminosity, the quality or condition of radiating or reflecting light.

star – 1. A celestial body that produces its own light and consists of a mass of gas held together by its own gravity. Nuclear fusion in the core of a star is the source of its energy. 2. Any of the celestial bodies visible at night from the Earth as relatively stationary, usually twinkling points of light, including binary and multiple stars.

Whole Picture:

Stars are celestial bodies located in the Milky Way galaxy that are capable of radiating light, that in many cases is visible from Earth. The brightness of this light has many dependent factors, such as distance of the star from Earth, the size of the star, the temperature of the star, and the color of the star.

Brightness of light is something that humans can determine by comparing the brightness of the light against other lights. Light from stars, flashlights, or any other source that radiates light can be compared against other similar types of light source, for example the brightness of one flashlight to another. A brightness magnitude scale was created in order to rank stars according to their luminosity and their proximity to Earth.

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In about 150 B.C., a Greek astronomer named Hipparchus invented the magnitude scale that ranked the stars in terms of their brightness. The ranking labeled the brightest stars with a 1 and the faintest stars with a 6. However, today with modern technology, astronomers are able to assign magnitudes less than 1 to stars that are very bright and magnitudes greater than 6 to stars that are very faint.

Astronomers use two different magnitude scales: apparent magnitude and absolute magnitude. Apparent magnitude is the scale that Hipparchus created, allowing rankings to be given based on how bright the stars appear to us from Earth. In this scale, a magnitude difference of 5 has been set to a factor of 100 times difference in intensity. Absolute magnitude is a comparison of stars' brightness from a set distance (32.6 light-years) away from the Earth. In this scale, -8 is the brightest ranking for stars and +16 is the faintest ranking for stars.

Apparent magnitude is the scale most individuals use since it is much easier to observe the brightness of stars from Earth than imagine the stars are 32.6 light-years away. The apparent magnitude scale can be applied to other sources of light, such as flashlights, which students will do to rank the brightness observed in several parts of this lesson.

Materials:

- Small (1 inch diameter) flashlight (1 per group)
- Medium (2 inch diameter) flashlight (1 per group)
- Large (3 inch diameter) flashlight
- Spot light (10 inch diameter) flashlight
- Batteries for all flashlights
- Measuring tape (1 per group) (metric and English units)
- Masking tape, enough for all groups to use
- Scientific calculator (1 per student/group)
- TEACHER INFORMATION SHEET: "Instructions for Modeling Activity"
- MULTIMEDIA: "Star Size Comparison" (http://apod.nasa.gov/apod/ap110222.html)
- TEMPLATE: "Shape Filters" (print on card stock or thick paper; 1 page per group)
- TEMPLATE: "Bulls-Eye Target" (1 per group / no less than 5)
- STUDENT LAB: "Star Brightness Lab"
- STUDENT WORKSHEET: "Modeling Brightness of Stars from Earth"

Activity Preparation:

1. Gather all materials needed. Print out a copy of the TEMPLATE: "Shape Filters" on card stock or thick paper for each group, and print out a copy of the TEMPLATE: "Bulls-Eye Target" for each group. You can save time during the lesson by cutting the shapes out ahead of time, or ask students to do this during the lab.
2. Ensure all flashlights are in proper working order with batteries installed.

Activity Procedure:

1. Ask the students what they know about stars. Ask leading questions that will initiate conversation about stars and their relative brightness.
2. Hand out the STUDENT LAB: "Star Brightness Lab." Discuss safety procedures for this lab, reminding students to not shine the flashlights in one another's eyes. Pair students up and provide them with the supplies needed.

   NOTE: Students need one small (1 inch diameter) flashlight, one medium (2 inch diameter) flashlight, one TEMPLATE: "Shape Filters," measuring tape, masking tape, and one TEMPLATE: "Bulls-Eye Target" per group.

3. Allow/help all groups set up their experiment. All groups should attach a bulls-eye target to the wall and place five measurements, one-meter separation between each, from the wall where the target is. Then

students should measure the diameter of the head of both flashlights and write those measurements in their lab handout. Lastly, ask students to cut out their shape filters so they have three black circles with shapes cut out of the middle.

4. Explain students should organize themselves so that they can find supplies easily because the room will be dark.
5. When all groups are setup and prepared to continue the lab, turn the room lights off.
6. Aid groups when needed in obtaining the information required in the lab.
7. Once all groups have finished collecting data, turn the room lights back on. Allow students to finish answering questions on the lab handout.

NOTE: Skip ahead to step 8 in the Activity Procedure and have students finish the math question on the lab handout afterwards if desired.

8. Using information from the Whole Picture section, explain that scientists have ranked the brightness of stars that are visible from Earth. Explain scientists use many factors when determining a star's relative brightness or luminosity magnitude, including distance from Earth and size of the star. Explain there are other factors as well, such as temperature and color. Describe the luminosity/brightness magnitude scales.
9. Explain the sun is considered the brightest star from Earth due to its proximity to Earth compared to other stars. Briefly describe what a light-year is and that the sun is only 8.1 light-minutes (0.0000154 light-years) away from Earth, and after that, the next closest star is 4.2 light-years away.
10. Explain the sun is much larger than Earth, however it is not the largest star in our galaxy. There are stars that are much larger than Earth. Show the multimedia video "Star Size Comparison" to visually clarify star size compared to other stars, as well as planets in our galaxy.
11. Handout the student worksheet "Modeling Brightness of Stars From Earth" and explain the students will be modeling bright stars that are visible from Earth. Use the Teacher Information Sheet "Instructions for Modeling Activity" to explain to students how the activity will be set up and conducted.
12. Help students set up all five flashlight displays. Turn off the lights and allow students to rank the brightness of all five "stars" on their worksheet. When all students have finished ranking the "stars" provide students with the ranking of the real stars amongst all other stars in the galaxy and amongst each other, which is listed on the TEACHER INFORMATION SHEET: "Instructions for Modeling Activity."

Critical Thinking Activity. ***Name of Critical Thinking Activity***. Tell students the North Star "Polaris" is listed as the 50th brightest star visible from Earth, but it is 430 light-years away. Ask students to write for one minute answering the following question: If the North Star is so far away, how can it be one of the brightest stars in the galaxy? (Teacher's Note: Polaris is 45 times bigger than the sun, which is why it is so bright!)

13. Instruct students to clean up the materials and to finish answering all questions on the lab handout and worksheet.

Extension Ideas:

1. Star Size and Distance Project: Have students create a 3-D model giving a size and distance comparison of bright stars compared to Earth.
2. Star Size and Distance Modeling: Have students create a scale drawing giving a size and distance comparison of bright stars compared to Earth.

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Answers:

STUDENT LAB: "Star Brightness Lab"

Prediction: Students should predict at least 1 factor affects star brightness. The answer to the testable question will be found during the lab activities.

Table 1: Answers may vary; correct observations will list Flashlight Brightness-ascending down the column listing 1-5, and Flashlight 1 Head Diameter should be about 2.5 cm.

1. d. They were all the same.

Table 2: Answers may vary; correct observations will list Brightest Flashlight as Flashlight 2 at all distances, and Flashlight 2 Head Diameter should be about 5 cm.

2. d. They were all the same.
3. a. Size and d. Distance
4. Size and distance.
5. The sun. Students should make an educated guess that the sun is either really close or really big to make it so bright.
6. Flashlight size may vary. Answers are examples for sizes given.

Diameter	Diameter Multiplied by	Flashlight at Star Size
2.5 cm	2.5	1,391,000
5 cm	5	2,782,000

STUDENT WORKSHEET: "Modeling Brightness of Stars from Earth"

1. a. 1, 5, 3, 4, 2.

   b. 1, 5, 3, 4, 2.

   c. Answers may vary, but may include problems with the flashlights or batteries or ambient light in the classroom influencing the investigation.

INSTRUCTIONS FOR MODELING ACTIVITY

TEACHER INFORMATION SHEET

Materials:

- One small (1 inch diameter) flashlight
- Two medium (2 inch diameter) flashlights
- One large (3 inch diameter) flashlight
- One spot light (10 inch diameter) flashlight
- Five bulls-eye targets
- Five desks/tables
- Measuring tape
- Masking tape

Procedure:

1. Place all five bulls-eye targets on the wall in a row with about three feet separation between each at the height of a desk.
2. See the Table: "Relative Distances of Stars," for scaled distances. Starting at the first target, measure the scaled distance for our sun, and place the small flashlight on a desk at that position. Mark that position as "Our Sun." (Relative sizes of stars/flashlights are listed in the table "Relative Sizes of Stars").
3. Moving to the next target, measure the scaled distance for Altair and place a medium flashlight on a desk at that position. Mark that position as "Altair."
4. Moving to target number three, measure the scaled distance for Capella and place the spot light flashlight on a desk at that position. Mark that position as "Capella."
5. Moving to the next target, measure the scaled distance for Procyon A and place the large flashlight on a desk at that position. Mark that position as "Procyon A."
6. Moving to the last target, measure the scaled distance for Sirius A and place a medium flashlight on a desk at that position. Mark that position as "Sirius A."
7. Turn on all flashlights and turn off classroom lights.
8. Students should go to each scaled model of the star distance and size and rank them relative to each another on the STUDENT WORKSHEET: "Modeling Brightness of Stars from Earth."
9. When all students have finished ranking, provide the apparent magnitude compared to all other stars visible from Earth as listed in the Table "Star Data." Review the definition of apparent magnitude (see Whole Picture) with students.
10. Instruct students to clean up materials as needed.

Table: Relative Distances of Stars (Scale: 1 light-year=1 foot)

Star Name	Star Size (solar diameters – relative to our sun)	Distance from Earth (light years)	Scaled Distance from Target (in feet)
Our Sun	1.0	0.000015	0.000015
Altair	1.6	16	16
Capella	13	41	41
Procyon A	2.6	11.4	11.4
Sirius A	1.9	8.6	8.6

Table: Relative Sizes of Stars

Star Name	Flashlight Representing Star Size
Our Sun	1 inch diameter (small)
Altair	2 inch diameter (medium)
Capella	10 inch diameter (extra large)
Procyon A	3 inch diameter (large)
Sirius A	2 inch diameter (medium)

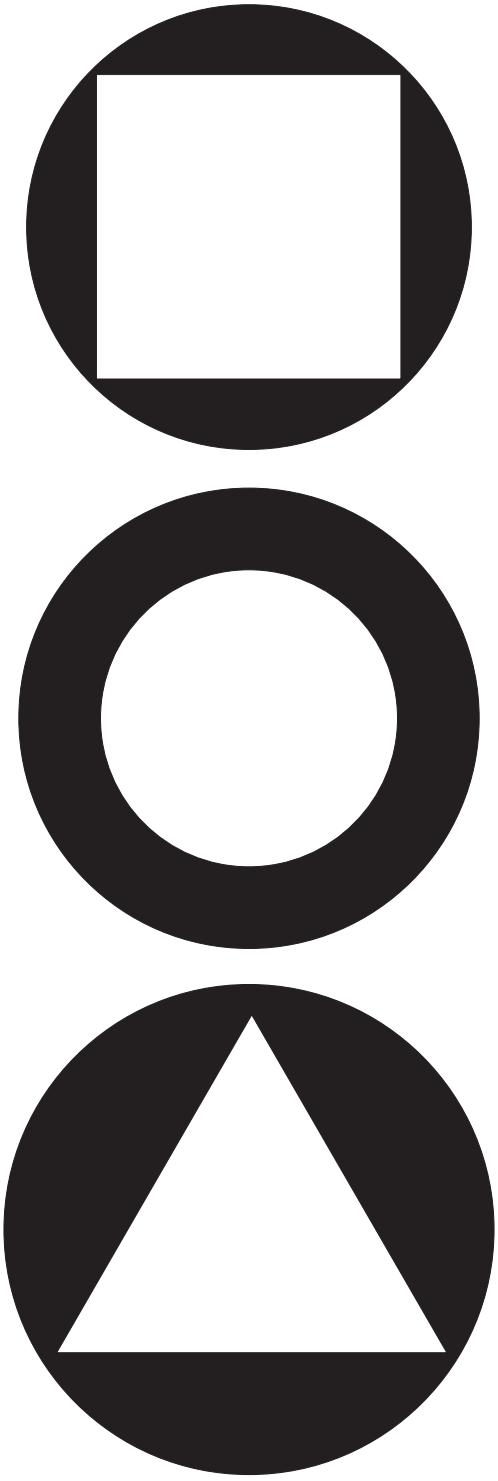
Table: Star Data

Star Name	Distance (Light Years)	Solar Diameter (Relative to the sun)	Apparent Magnitude	Star Ranking (Compared to all stars)	Star Ranking (Compared to these 5 stars only)
Our Sun	0.0000154	1.0	-26.72	1	1
Altair	16	1.6	0.77	13	5
Capella	41	13	0.08	7	3
Procyon A	11.4	2.6	0.34	9	4
Sirius A	8.6	1.9	-1.46	2	2

SHAPE FILTERS

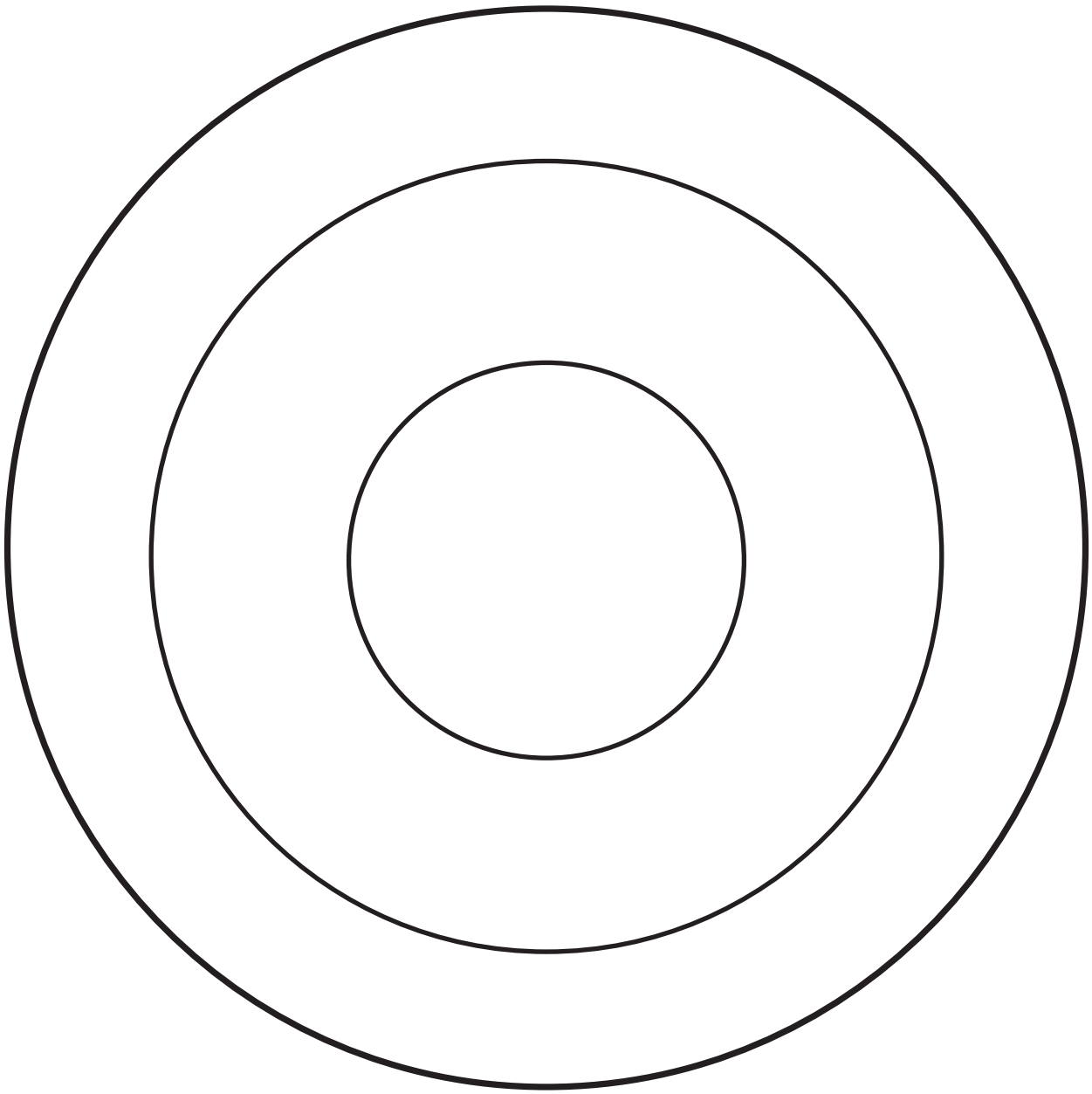
TEMPLATE

Copy on card stock or thick paper. Make one sheet for every group. Cut away all white, leaving three filters with different shapes in the middle



BULL'S-EYE TARGET

TEMPLATE



NAME: _____

STAR BRIGHTNESS LAB

Testable Question:

Are distance, shape, size, and movement factors that affect star brightness?

Prediction:

Predict which of the factors listed affect star brightness:_____.

Investigation:

Materials:

- flashlights (2: one small and one medium)
- shape filters (3: cut out of "TEMPLATE: Shape Filters")
- measuring tape
- masking tape
- bulls-eye target
- scientific calculator

Safety:

Be careful using the flashlights. Don't shine the light in anyone's eyes. This can be very painful and can cause damage.

Procedure:

1. Obtain all needed supplies from teacher.
2. Take bulls-eye target and tape it to a spot on the wall as "Earth" position.
3. Starting from "Earth" position, move out from the wall and measure, mark and label the following distances on the floor with masking tape: 1 meter, 2 meters, 3 meters, 4 meters, and 5 meters.
4. Select the small flashlight and measure the diameter of its head in centimeters and list that measurement in Table 1. Set aside to use in Step 8; this flashlight will be called Flashlight 1.
5. Select the medium flashlight and measure the diameter of its head in centimeters and list that measurement in Table 2. Set aside to use in Step 10; this flashlight will be called Flashlight 2.
6. When you have reached this step, let your teacher know so that he or she can turn off the lights.
7. When observing brightness in this lab, be sure to look at the bulls-eye target to determine the brightness based on how bright the light shines on the target.

Distance:

8. Using Flashlight 1, stand at each of the marked distances and shine the flashlight at the bulls-eye target.
9. Rank the brightness of the light at each distance compared to the other distances in Table 1.

Shape:

10. Using Flashlight 2 and the shape filters, stand at your 2 meter mark.
11. Cover the flashlight head with the three different shapes one at a time, and shine the light at the bulls-eye target, comparing the brightness of all three shapes.
12. Answer Data Question 1.

Size:

13. Using Flashlight 1 and Flashlight 2, stand at each of the marked distances and shine each flashlight at the bulls-eye target, one at a time.
14. In table 2 circle which flashlight was brightest at each distance.

Movement:

15. Using Flashlight 1, stand at your 2 meter mark.
16. Shine the light at the bulls-eye target and move the light in very fast circles, then slow circles, and lastly don't move the light, comparing the brightness of all three movements.
17. Answer Data Question 2.
18. Clean up all lab materials as teacher instructs.
19. Answer all questions in lab handout.

Data:

Table 1:

Distance (m)	Flash Brightness (1 brightest - 5 dimmest)	Flashlight 1 head diameter (cm)
1		
2		
3		
4		
5		

1. Choose the result you observed in Step 10. (circle one)

   A. Circle shape was the brightest.
   B. Square shape was the brightest.
   C. Triangle shape was the brightest.
   D. They were all the same.

Table 2:

Distance (m)	Brightest Flashlight (circle one in each box)	Flashlight 2 head diameter (cm)
1	Flashlight 1 / Flashlight 2	
2	Flashlight 1 / Flashlight 2	
3	Flashlight 1 / Flashlight 2	
4	Flashlight 1 / Flashlight 2	
5	Flashlight 1 / Flashlight 2	

2. Choose the result you observed in Step 16. (circle one)

   A. Fast movement was the brightest.
   B. Slow movement was the brightest.
   C. No movement was the brightest.
   D. They were all the same.

Analysis of Data:

3. Which factors affected flashlight brightness? (circle all that apply

   A. Size B. Shape C. Movement D. Distance

Conclusion:

4. Using your answer from Question 3, which are the factors that affect star brightness? Check to see if your prediction was correct. _____

5. What is the brightest star that humans can see from Earth, and why is it so bright?

   _____

Further Questions:

11. Use the following ratio to scale up flashlight diameter to star diameter:

Actual Diameter	**Star Diameter**
1 centimeter (cm)	556,400 kilometers (km)

Actual Flashlight (FL) Diameter (cm)	Flashlight diameter multiplied by star diameter	Flashlight at Star Size (km)
FL 1:		
FL 2:		

NAME: _____ STUDENT WORKSHEET

MODELING BRIGHTNESS OF STARS FROM EARTH

Directions: The teacher will set up the activity using the tables below. When all the lights in the classroom are off, go to each scaled model of star distance and size and rank them compared to each other in the "Flashlight Brightness" column. The teacher will provide the data for "Apparent Star Magnitude.".

1. Fill in the empty columns:
   a. Observed brightness: Rank the brightness of all five flashlights from 1-5, one being the brightest.
   b. Brightness of actual stars: List the apparent star magnitude for all five stars. Teacher will provide the Apparent Star Magnitude.

Flashlight / Star	a. Flashlight Brightness	b. Apparent Star Magnitude
Small / Our Sun		
Medium / Altair		
Extra large / Capella		
Large / Procyon A		
Medium / Sirius A		

Table: Relative Distances of Stars (Scale: 1 light-year = 1 foot)

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